The Petroleum Situation

B1900-2 3/2/83

Vol. 6 – No. 3
DECEMBER, 1982

THE CHANGING DIMENSIONS OF THE NATURAL GAS SUPPLY/DEMAND BALANCE

Since the passage of the Natural Gas Policy Act of 1978 (NGPA), the U.S. supply conditions for natural gas have changed dramatically. At the time the Act was being debated, the major issue concerned gas pricing in the face of a supply shortage induced by the past effects of artificially low gas prices which had encouraged consumption while discouraging exploration and production. The lawmakers devised a complex set of categories for gas prices, ranging from old gas which would remain under price controls, to categories to be decontrolled, namely deep gas (below 15,000 feet) and, eventually, gas produced from tight sands. Ceiling prices for the gas in categories to be decontrolled were to move up gradually according to formulas based on the rate of inflation. The January 1, 1985 date for complete decontrol of these categories envisioned a target price in BTU equivalents equal to $15 per barrel crude oil, in 1978 dollars.

Following the passage of the NGPA, restrictions also were placed on the use of gas by industry and electric utilities in the Powerplant and Industrial Fuel Use Act. This Act sought to foster energy self-sufficiency and restrict the use of gas and oil by industry and utilities, in an effort to ensure adequate supplies for priority uses such as residences and hospitals, etc. In simple terms, the Act specifically prohibited the use of natural gas in new electric powerplants and major fuel-burning installations (MFBIs) and also gave the Department of Energy the authority to prohibit natural gas use in existing powerplants and MFBIs.

Another action designed to favor home heating over industrial use was the incremental pricing provision of the NGPA. Under this provision, the difference between the cost of "expensive gas" and a base figure which would be escalated with inflation* would be put in a special fund and allocated across industrial customers who were using gas as a boiler fuel. The NGPA provided, however, that the price charged to industrial customers could not exceed the price of competing fuels.

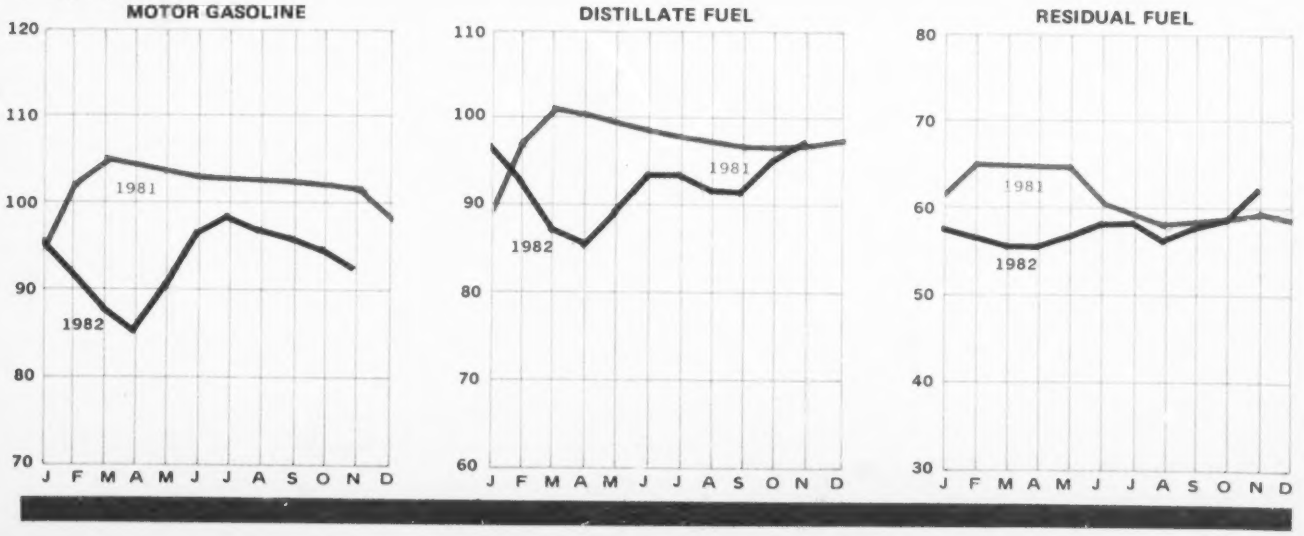
Gas Price and Demand

It is difficult to accurately estimate the impact of gas price changes on demand in the context of the complex regulations governing pricing and use of natural gas. Nevertheless, it is safe to say that the incremental pricing provisions of the NGPA tended to discourage natural gas use by existing industrial customers, as well as by those exempted under the fuel use regulations. Further complicating the situation was the oil price shock of 1979-1980.

The price shock, which followed the Iranian revolution, changed the parameters of natural gas decontrol by outdating the $15 per barrel (1978 dollars) crude equivalent price target for January 1, 1985. Lawmakers and people in the industry began discussing the "fly-up" problem which would occur in 1985 when controls would be lifted on all but old gas. At the time, forecasts of 1985 crude oil price were in the neighborhood of $30 per barrel in 1978 dollars, twice as high as the NGPA target price.

*Expensive gas includes most higher priced gas sources such as deep gas, tight sands gas, stripper gas, LNG and other imports, and "new gas" which has the highest price of the categories of decontrolled gas. The various types of expensive gas are measured against different base prices, all of which are escalated by some formula which is tied to inflation.

U.S. Wholesale Prices . . .
BY MONTH
cents per gallon



Concerned with securing adequate supplies in an environment of renewed worries regarding oil price and availability, many distributors willingly signed contracts with gas producers for decontrolled gas. In a typical contract, the price was determined by an escalation clause ensuring that prices would continue to rise. Both for technical reasons (relatively stable flow rates are important for both deep gas and gas from tight sands) and because of the higher costs associated with finding and producing the gas, producers frequently insisted on strict take-or-pay provisions. A take-or-pay provision puts an obligation on the purchaser to buy a minimum volume of gas or to pay for the gas not lifted.

Unfortunately, gas market dynamics are not readily predictable. The demand for natural gas has been negatively affected, both by the recession of 1981-1982 and by fuel substitution, as shown in Table A.

TABLE A

U.S. ENERGY CONSUMPTION BY SECTOR
JANUARY – JULY 1982

(Percent Change from Year Ago)

	Resident./ Commercial	Industrial	Transportation	Electric Utilities	Total
Natural Gas	4.7	−9.6	−4.2	−12.6	−4.1
Petroleum	−3.5	−8.6	−2.5	−16.1	−5.1
Coal	14.6	−7.7	–	0.0	−1.5
Other*	–	0.0	–	12.6	12.6
Total Primary Energy	2.6	−8.9	−2.6	− 0.4	−2.6
Electricity Sales	1.9	−8.6	0.0		−2.1

*Includes nuclear, hydropower, geothermal, wood and waste materials.
Source: Department of Energy, *Monthly Energy Review.*

In the electric utility sector, there is clear evidence of fuel substitution away from both natural gas and oil. Non-fossil sources of power generation in total are continuing to grow in the context of fairly flat demand for electricity. While total fossil fuel consumption at electric utilities from January through July, 1982 was 4.5 percent below the same period in 1981, coal use remained steady, oil declined 16.1 percent and natural gas was down 12.6 percent. Although electricity sales can be expected to turn around when the economy recovers, substitution of coal for oil and natural gas will continue.

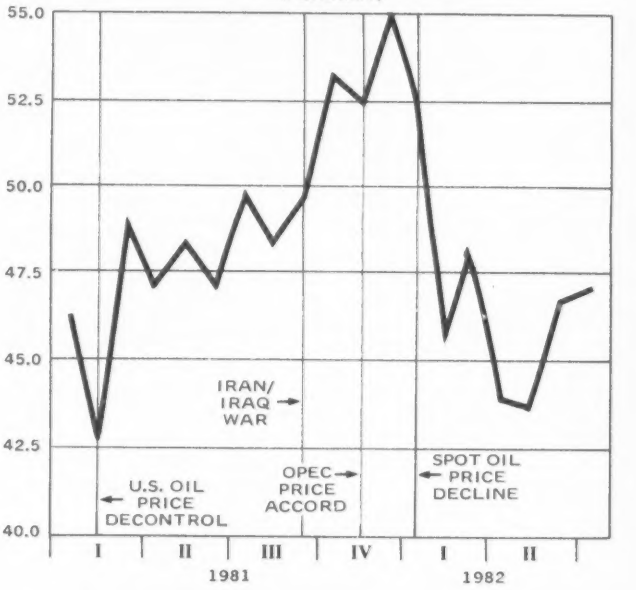
Residential and commercial consumption of gas increased by 4.7 percent on average in the first seven months of 1982 versus the comparable period in 1981. Electricity sales grew 1.9 percent while oil use fell by 3.5 percent. In this sector, substitution away from oil is continuing. But this trend may not continue much longer, or at least not to as great an extent, since natural gas prices have been rising much more quickly than oil prices. Oil prices, in general, began declining in real terms beginning in the second quarter of 1981. Natural gas prices, however, continued to rise due to the price escalation clauses in supply contracts and NGPA.

For example, in the first half of 1982, the average price of natural gas to the retail market was up 20 percent in current dollars, and nearly 13 percent in real terms compared to the first half of 1981. The retail price of heating oil, on the other hand, declined by almost 4 percent in current dollars and 10 percent in real terms. On a BTU equivalent basis, however, the cost of oil heat is still roughly 1.5 times the cost of gas heat.

Industrial activity is off sharply, leading to substantial declines in energy use across the board. But there is marked evidence of fuel substitution in the industrial sector as well. For the first seven months of 1982, industrial energy consumption was 8.9 percent lower than in the same period in 1981. Coal use was off 7.7 percent, oil 8.6 percent, and natural gas demand fell by 9.6 percent, implying a loss of market share for gas.

Industrial facilities which burn natural gas quite often are equipped to burn oil as well since many industrial users have interruptible gas contracts. Thus, relative prices and price expectations between oil and gas play an important role in determining market shares. Figure 1 plots the natural gas share of the consumption of oil and gas by the industrial sector. Also shown are the events which heavily influenced consumer price expectations. As shown, the share of natural gas in the oil/gas mix rose during 1981, coinciding with the events producing expectations of rising oil prices. For instance, U.S. oil prices were decontrolled at the end of January, 1981, Iran and Iraq went to war in September, 1981, and OPEC came to what proved to be a temporary pricing agreement in late October, 1981, formalizing higher prices. In short, while natural gas prices continued to increase during 1981, there was a lot more uncertainty about future oil prices than gas prices. This situation changed dramatically in 1982.

FIGURE 1
NATURAL GAS SHARE OF INDUSTRIAL
OIL AND NATURAL GAS CONSUMPTION
(PERCENT)



Early in 1982, spot oil prices began to erode precipitously as a result of recession, inventory drawdown, and excess OPEC production. Even greater oil price erosion was a distinct possibility and the topic of great discussion. At the same time, concern was growing over the outlook for natural gas prices in light of take-or-pay contracts and the pricing provisions of the NGPA. In this climate, industrial users apparently began to shift back toward oil from natural gas, as shown in the figure.

A complete analysis of the changing markets for natural gas in the industrial sector, recognizing changes in the mix of industrial activity and spatial relationships on a regional basis, is necessary to fully understand the current market situation. Nevertheless, one thing is clear. The ability is there for the market to respond rapidly to changes in market signals, especially in the industrial and electric utilities sectors. Even homeowners have been increasing their fuel choice flexibility with the addition of kerosene space heaters and wood stoves. Expectations of further rapid increases in natural gas prices in conjunction with stable or even declining oil prices could easily lead to further erosion of the natural gas share of U.S. energy consumption, causing additional difficulties for the nation's gas industry.

The Problem of Take-or-Pay in the Face of Weak Oil Markets

As a result of the high-priced, take-or-pay contracts and the escalation clauses they contain, a considerable quantity of the gas supply contracted to some pipelines soon could be priced well above market clearing levels. For example, as things now stand, some major pipelines would wish to charge $7 or more per thousand cubic feet to their major industrial customers by 1985. This equates to around $42 per barrel in current dollars for low-sulfur fuel oil, which is substantially higher than Chase's best estimate forecast of $35 per barrel for such fuel oil. By contrast, other pipelines could have costs as low as

$4.75 per thousand cubic feet in 1985, equivalent to $28 per barrel of fuel oil.

The take-or-pay provisions add another dimension to the pricing problem. With falling demand, pipeline companies first cancel the supplies which are not subject to take-or-pay clauses. Next they cancel delivery of the lowest cost gas which is subject to take-or-pay provisions. These tend to be such categories as old gas, the price of which is currently not scheduled to be decontrolled. "Shutting in" the cheapest source of supply makes the average price rise even faster, which causes consumers to use even less gas. More gas is then shut-in, leading to the possibility of a falling demand/rising price spiral that could be difficult to stop.

This spiral need not occur, of course, as it is not in the long-term interests of residential or industrial consumers, distributors, pipelines or producers. At this point government action does not seem to be the answer. Producers and transmission companies both face considerable pressure to re-negotiate some past contracts. Major changes in market conditions, which neither party could have reasonably contemplated, have occurred. Indeed, many pipeline companies have already negotiated new arrangements with their gas suppliers. Additional government involvement almost certainly would only serve further to obfuscate a situation already confused enough by regulations.

Susan Haltmaier Todd, 2VP
Colin P. Carter, VP

WORLD PETROLEUM HIGHLIGHTS

Supply And Demand

There are two major areas of interest in the recent supply/demand data. The first is the continuing rise in domestic oil production, both in Alaska and the lower 48 states. Through the end of October, 1982 production averaged 92,000 barrels per day more than in 1981, a total increase of almost 28 million barrels of oil. The major part of this increase has come from Alaskan oil (90 thousand barrels per day), but that lower 48 production has even leveled off is a notable event. Between 1973 and 1980 the decline averaged 3.7 percent per year. In 1981 the drop was only 0.2 percent and 1982 may show a very slight rise. If the 3.7 percent per year decline had continued, oil production in the lower 48 states would have been 475,000 barrels per day lower than it is currently.

The savings on oil imports of the higher domestic output is over $6 billion per year. In 1979 the U.S. oil import bill was just about $48 billion. In 1982 the bill will be about $37 billion, $11 billion lower. Without the increase in domestic production, the drop would have been less than half of this figure.

The second area of major interest is the drop in oil product demand, which is the second prime cause of the sharp reduction in our expenditure on foreign oil. After some indication of a fall-off in the rate of decline in early summer, that rate has accelerated again with an October decline of 3.6 percent over October, 1981. As in the previous months, it is fuel oil, particularly heavy fuel oil, that is taking the brunt of this decline (the decline in residual fuel use represents 85 percent of total oil product decline). It is stating the obvious to point to the low level of industrial activity as a major factor behind this decline. The concern of the oil industry is the extent to which this decline in demand will be reversed with improvement in economic activity.

It is interesting to note that while residual oil demand has shown the largest decline of any product, residual oil stocks are below year-ago levels by a relatively larger amount than crude oil or any other product. At the end of October, 1982, stocks of residual fuel oil were 60.9 million barrels, 19 million barrels or nearly 24 percent below the year-earlier level. Imports of residual fuel oil totalled almost 23 million barrels less in the 12 months from November, 1981 through October, 1982 than in the preceding 12-month period. In addition, proportionately more of the 2.3 million barrels per day of refinery capacity that is currently shut down in the U.S. consists of simple, topping facilities which have a higher yield of residual fuel than newer, more sophisticated facilities. This implies that the percentage yield of residual fuel in total crude runs to refineries would fall. For example, residual fuel oil yield has fallen from 10.3 percent in October, 1981 to under 9 percent in October, 1982.

Japanese Refinery Margins

Ex-refinery, crude oil and product prices in Japan are shown in Table 1. The refinery spreads are then shown in Table 2.

TABLE 1
CRUDE OIL AND PRODUCT PRICES IN JAPAN
– 1982 –
(Dollars Per Barrel)

	APR.	JULY	AUG.	SEPT.
Crude Oil	36.00	35.00	34.50	35.00
Gasoline	63.00	58.75	61.25	60.25
Naphtha	36.10(R)	33.00	32.45	31.91
Middle Distillate	51.40	49.30	51.00	50.00
Residual Fuel	40.43	34.50	35.00	34.42

R = Revised from previous Petroleum Situation.

TABLE 2
JAPANESE REFINERY MARGINS
– 1982 –
(Dollars Per Barrel)

	APR.	JULY	AUG.	SEPT.
High Conversion	11.05	8.05	9.59	8.32
Low Conversion	8.72	4.99	6.36	5.15

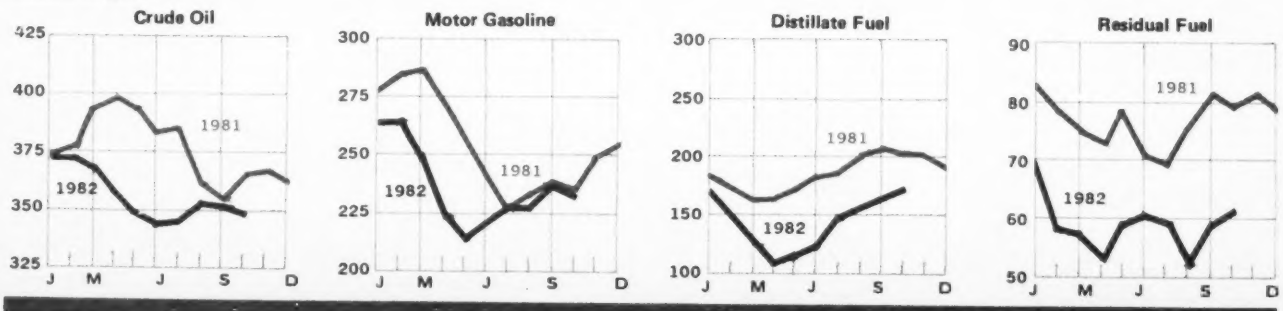
Note: High conversion yield: gasoline 18%, naphtha 17%, middle distillate 30%, residual fuel 35%.
Low conversion yield: gasoline 11%, naphtha 9%, middle distillate 20%, residual fuel 60%.

After recovering slightly in August, Japanese refinery margins began to fall again in September to levels just above the July figures. These margins are substantially greater in dollar terms than the U.S. and European figures. Recall that these spreads must cover operating costs and profit. Operating costs for Japan include a much greater level of interest than is common for the U.S. or Europe.

(continued on page 4.)

Petroleum Inventories BY MONTH

millions of barrels



European Refinery Margins

European crude oil and product prices are given in Table 3. The refinery spreads for Europe shown in Table 4 reflect the very poor (negative) margins that have prevailed throughout the year. In Europe, while margins improved in September, low conversion refineries continued to show large negative margins.

TABLE 3
EUROPEAN CRUDE OIL AND PRODUCT PRICES
– 1982 –
(Dollars Per Barrel)

	APR.	JULY	AUG.	SEPT.
Crude Oil	32.00	33.00	33.10	33.25
Gasoline	32.28	36.10	36.30	37.10
Naphtha	32.00	35.50	35.70	34.50
Middle Distillate	38.01	36.20	37.10	39.10
Residual Fuel	26.10	24.10	24.20	25.10

TABLE 4
EUROPEAN REFINERY MARGINS
– 1982 –
(Dollars Per Barrel)

	APR.	JULY	AUG.	SEPT.
High Conversion	0.47	–0.17	0.14	1.01
Low Conversion	–1.71	–3.54	–3.32	–2.51

Note: High conversion yield: gasoline 30%, naphtha 10%, middle distillate 33%, residual fuel 27%.
Low conversion yield: gasoline 10%, naphtha 10%, middle distillate 25%, residual fuel 55%.

U.S. Refinery Margins

As shown in Table 5, the recovery in Type 1 refinery margins that was hoped for over the summer did occur. Even Type 2 units developed a small positive spread in October. The November figures, however, reflect the start of the collapse in product prices, and it is anticipated that December figures will show a marked worsening.

TABLE 5
U.S. REFINERY MARGINS
(Dollars Per Barrel)

	Type 1 Refinery	Type 2 Refinery
1975	1.21	0.10
1978	2.39	0.10
1979	4.19	0.84
1980	4.09	–1.97
1981	4.07	–1.77
January, 1982	3.83	–1.74
February, 1982	2.94	–2.22
March, 1982	2.97	–1.77
April, 1982	3.16 (R)	–1.27 (R)
May, 1982	4.56 (R)	–0.31 (R)
June, 1982	5.86 (P)	0.26 (P)
July, 1982	6.13 (P)	0.36 (P)
August, 1982	5.32 (P)	–0.52 (P)
September, 1982	5.07 (E)	–0.35 (E)
October, 1982	5.24 (E)	0.01 (E)
November, 1982	4.85 (E)	–0.25 (E)

R = Revised, P = Preliminary, E = Estimate

Note: Assumed Type 1 and 2 yields are:

	Motor Gasoline	Kerosene	Distillate Fuel	Residual Fuel
Type 1	50%	8%	25%	17%
Type 2	21%	8%	19%	52%

	OCTOBER			3 MOS. AVERAGE			YEAR-TO-DATE		
	1982	1981	Change	1982	1981	Change	1982	1981	Change
	Thous. Bbls. Daily		– % –	Thous. Bbls. Daily		– % –	Thous. Bbls. Daily		– % –
PRIMARY DEMAND									
Motor Gasoline	6,608	6,578	0.5	6,575	6,625	– 0.8	6,550	6,599	– 0.7
(Unleaded)*	3,529	3,250	8.6	3,555	3,231	10.0	3,410	3,223	5.8
Jet Fuel	966	934	3.4	1,016	997	1.9	1,007	1,013	– 0.6
Kerosine	143	134	6.7	116	107	8.6	124	118	5.5
Distillate Fuel	2,636	2,803	– 6.0	2,453	2,569	– 4.5	2,677	2,785	– 3.9
Residual Fuel	1,381	1,884	– 26.7	1,495	1,873	– 20.2	1,715	2,089	– 17.9
All Other	3,434	3,492	– 1.7	3,257	3,413	– 4.6	3,195	3,450	– 7.4
Total Domestic Demand	15,168	15,825	– 4.2	14,911	15,583	– 4.3	15,268	16,054	– 4.9
Exports	800	738	8.4	793	635	25.0	793	578	37.2
Total Demand	15,968	16,563	– 3.6	15,704	16,218	– 3.2	16,061	16,631	– 3.4
New Supply									
Domestic	10,548	10,878	– 3.0	10,796	10,689	1.0	10,829	10,787	0.4
Crude Oil	8,658	8,563	1.1	8,670	8,583	1.0	8,661	8,569	1.1
Natural Gas Liquids	1,536	1,598	– 3.9	1,530	1,608	– 4.9	1,537	1,608	– 4.5
Other Supply	354	717	– 50.6	596	498	19.6	632	610	3.6
Imports	4,841	5,487	– 11.8	4,856	5,616	– 13.5	4,778	5,763	– 17.1
Crude Oil	3,530	3,929	– 10.2	3,525	4,036	– 12.7	3,313	4,206	– 21.2
Refined Products	1,311	1,558	– 15.9	1,331	1,580	– 15.8	1,465	1,558	– 6.0
Residual Fuel	609	786	– 22.5	668	815	– 18.0	737	780	– 5.6
All Other	702	772	– 9.1	663	765	– 13.4	728	777	– 6.3
Total New Supply	15,389	16,365	– 6.0	15,652	16,306	– 4.0	15,607	16,550	– 5.7
Crude Oil Refined	11,725	12,364	– 5.2	11,928	12,772	– 6.6	12,097	12,774	– 5.3
Stock Change	–579	–198	–	–52	88	–	–454	–81	–
Stocks – End of Month in Million Barrels									
Gasoline	232	236	– 1.6						
Jet Fuel	41	43	– 4.8						
Kerosine	11	13	– 14.7						
Distillate Fuel	171	201	– 14.9						
Residual Fuel	61	80	– 23.7						
All Other	260	332	– 21.8						
Total Products	775	904	– 14.3						
Crude Oil	349	364	– 4.1						
Total – All Oils	1,124	1,268	– 11.3						

Totals may not add due to rounding
*Included in motor gasoline

Sources: *American Petroleum Institute*
Chase Manhattan Bank
Department of Energy

THE IMPACT OF AN OIL PRICE COLLAPSE EXAMINED IN THE 1983 EDITION OF CHASE'S ENERGY STUDIES

- **The Energy Outlook Through 2000**
- **Petroleum Industry Investments in the Eighties**
- **World Coal Outlook to the Year 2000**

Over the past year, there have been two significant market developments which, taken together, greatly affect the long term expectations for energy and the energy industries of the world. First, the continuation and deepening of the worldwide recession in 1982, coupled with a perceived change in the structure and pattern of economic development and expansion over the long term, have led to lowered forecasts of economic growth. Economic projections are now calling for a delayed recovery from the current recession and lower rates of economic growth once the recovery begins.

Second, a supply/demand imbalance in the oil market, which is the product of recession, energy conservation, energy substitution, and excess OPEC production, has led to a major weakness in oil prices, both spot market and effective non Saudi contract prices. The potential for continued market weakness, because of the slow rate of economic growth and the inability of OPEC to control production, has led to a projection of lower oil price paths than had been forecasted previously.

In light of these developments, the Chase Energy Economics Division has updated the three energy-related publications released in October, 1981. The reports, the product of an integrated multi disciplinary assessment of the world energy market outlook, are a blend of judgment and mathematical analyses developed via a family of large-scale computerized simulation models. The studies are described in detail below.

The Energy Outlook Through 2000

The 1983 edition includes more detailed regional forecasts of energy demand by fuel type that are consistent with the latest views regarding economic growth, oil prices, and energy conservation. Major emphasis is placed on oil as the marginal energy supply with considerable analysis regarding OPEC's current dilemma in controlling production to maintain the marker price and sustain member countries revenue stream. A MAJOR CONCLUSION OF THE STUDY IS THAT OPEC WILL CONTINUE TO FACE FINANCIAL PRESSURES OVER THE BALANCE OF THE DECADE. In this context, the production profiles and revenue streams of the OPEC members are examined under two oil price scenarios. The first scenario represents our 50 percentile (best estimate) forecast wherein OPEC is successful in defending the current $34 marker crude price. In the second oil price scenario a continuation of the current recession and OPEC's inability to control production results in a marker crude price collapse to $26 in 1983. At present a 25 to 35 percent likelihood is assigned to this event. The study concludes with an assessment of such unconventional energy sources as nuclear fusion. Below we provide The Table of Contents of the study. The report is available for $175 (U.S.). Additional copies cost $85 each.

The Energy Outlook Through 2000

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Petroleum Industry Investment in the Eighties

The 1983 edition of this report provides an in-depth analysis of the non-Communist petroleum industry's capital expenditures through 1990, updated to include actual 1980 and 1981 results and to be consistent with the current best estimate oil price forecast and its impact on industry cash flow and return on E&P investment expectations. The analysis includes regional forecasts of investment needs in exploration and production, refining, petrochemicals, transportation, and marketing. Based on these investment needs, the non-Communist world petroleum industry's credit market requirements are forecast. In addition, the report focuses in detail on the U.S. petroleum industry's projected source and use of funds. It also examines the impact of an OPEC oil price collapse scenario on capital investment and credit market requirements. The scenario used involves an $8 per barrel drop in the marker crude price to $26 per barrel in the second quarter of 1983. "Petroleum Industry Investments in the Eighties" is available for $100 (U.S.). Additional copies cost $50 each.

World Coal Outlook to the Year 2000

The 1983 edition of the "World Coal Outlook to the Year 2000" examines the worldwide impact of lower oil prices and lower economic activity on the demand, production, and international trade in coal. The report includes detailed regional forecasts of coal demand by end-use application. Regions include the U.S., Canada, Western Europe, Japan, Other Asia, Latin America, Africa, Australia/New Zealand, Communist Europe, and Communist Asia. In addition, regional coal production forecasts are provided with a detailed analysis of regional coal trade patterns. In all instances, the changes relative to Chase's previous forecasts are shown. Because of the current situation in the oil market, the report includes an analysis of the competitive position of coal relative to oil in the generation of electricity, and in industrial steam applications. The report concludes with an examination of the impact of an oil price collapse on the international markets for coal. At present a 25 to 35 percent likelihood is assigned to this event occurring in 1983. The study is available at $125 (U.S.), payable by check or money order to The Chase Manhattan Bank, N.A. Additional copies cost $65 each.

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The Petroleum Situation

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VOLUME 7 – NO. 1
MARCH, 1983

PETROCHEMICALS AND PETROCHEMICAL FEEDSTOCKS

The origin of the petrochemical industry is usually traced to the start-up of the propylene-based isopropanol plant by Standard Oil of New Jersey (now Exxon) in 1929. Hence, the industry is fifty-four years old and hardly a newcomer on the industrial scene. But the industry did not begin to consume significant volumes of petroleum until the 1960s. By 1965, total feedstock consumption by WOCA (World Outside Communist Areas), excluding natural gas, represented about 1.3 million barrels of oil per day, or 5 percent of total crude produced. Estimated consumption in 1981 was around 3.7 million barrels per day or 8 percent of crude production.

While a plethora of products may be derived from petroleum, two basic processes are the starting point for almost all petrochemicals. The first is the cracking of petroleum products in the presence of steam (steam cracking) to produce ethylene and similar products. The second is the reforming of petroleum and the extraction of aromatic compounds such as benzene. In addition to the basic processes, the production of ammonia via petroleum-based synthesis gas is commonly considered a petrochemical process. This article describes these three processes and reviews their current and future place in the pattern of oil consumption.

Steam Cracking

In this process, hydrocarbons are thermally cracked in the presence of steam using directly fired tubular furnaces with fairly short residence time. The presence of steam enhances the production of the desired products compared with straight thermal or catalytic cracking.

A wide range of hydrocarbon feedstocks can be used for the steam cracking process, from ethane down to a vacuum gas oil (V.G.O.) boiling in the 650 to 1000°F range. The prime product is ethylene, but other products are produced depending on the feedstock. Three groups of feedstock are commonly used: natural gas liquids such as ethane, propane or butane; naphtha, a hydrocarbon boiling in the gasoline range; and V.G.O. Approximate yields from these feedstocks are shown in Table A. The main products are olefins, a generic term for a group of products that have one or more reactive double bonds between two of the carbon atoms. Ethylene, propylene, and butenes have one such double bond each and butadiene has two such double bonds. These products are used to make plastics, synthetic rubbers, synthetic fibers, and solvents. Steam-cracked naphtha is also a product in the gasoline boiling range with a high aromatic chemical content. The fuel oil stream shown in Table A includes all products that have higher boiling points than naphtha.

TABLE A

APPROXIMATE STEAM CRACKING YIELDS

(Weight Percent of Feedstock)

	Natural Gas Liquids	Naphtha	Vacuum Gas Oil
Ethylene	64	23	22
Propylene	8	16	14
Butenes	2	9	7
Butadiene	2	5	4
Fuel Gas	21	17	10
Steam-Cracked Naphtha	3	26	20
Fuel Oil	–	6	23
	100	100	100

The cost per ton for the common feedstocks varies considerably, with ethane costing as little as $130 per ton, propane $190 to $200 per ton, naphtha $270 to $280, and V.G.O. around $200 per ton at present. The general volatility of prices for petroleum products has also applied to these feedstocks. This has been compounded by changes in the relative value of the streams, one to another. Since these feedstock streams are used in many other ways, and steam cracker feedstock is in no case the primary use of each product, the relative economics of each feedstock has varied considerably.

As an example, when it generally was expected that natural gas production in the U.S. was going to be declining (in the mid-1970s), it was thought that the production of gas liquids (ethane, propane, and butane) would also decline. Hence, it was assumed that the use of these products as steam cracker feedstock would become less economic and would decline. In fact, the prime trend of the 1979-1982 period has been the rising importance of these natural gas liquid feedstocks. In addition, with the increase in the discount for heavy oil products that has been a feature of the oil market for the last four years, the economics of V.G.O. cracking would have been anticipated to improve. Due partly to an increase in the trade for this stream as feedstock for catalytic crackers, and partly to the much lower than expected prices for gas liquids, the economics of gas oil cracking is still not good. The complex factors influencing the economics of steam cracker feedstocks make it impossible to predict with certainty which will be the optimum feedstock in the future.

Reforming and Aromatics Production

Aromatic chemicals are based on a ring of six carbon atoms, often depicted as containing three of the same double bonds that make the olefins so reactive. In fact, this ring of six carbons (the benzene ring) is remarkably stable. The common aromatic products are benzene, toluene, and the three xylenes, ortho, meta and para. These formulae are shown below. A very wide range of chemicals, plastics fibers, solvents, drugs, etc., are based on these compounds, but benzene is both the simplest and the most widely used of the aromatic compounds.

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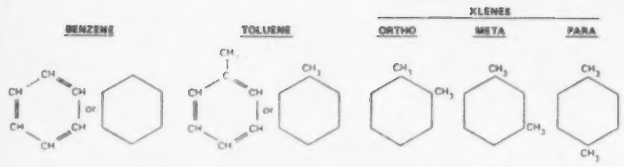


About half of the world's aromatic production is based on the aromatic-rich steam-cracked naphtha produced by steam cracking naphtha or V.G.O. The other half is derived from catalytically reformed naphtha (reformate). This process involves the production of the cyclic compounds with no double bond (naphthenes) from straight-linked hydrocarbons and the removal of hydrogen from these compounds to yield aromatics. This occurs by passing virgin naphtha, the part of crude oil that boils in the same range as gasoline, over a noble metal catalyst (platinum, rhenium, etc.) in a reformer. While there are some differences between steam-cracked naphtha and reformate, both are mixtures of aromatics (about 50-70 percent by volume) and other hydrocarbons. The mixture cannot be separated by distillation, and some form of extraction process has to be used. The mixture of aromatics then is separated into its components by distillation or, in the case of paraxylene, by fractional crystallization.

While aromatics represent a large proportion of petrochemical production (about 40 percent of olefin production) they are still primarily by-products. About half the aromatics are based on a by-product of steam cracking and the balance on a by-product of reforming naphtha to make it suitable for use in gasoline. Since both steam-cracked naphtha and reformate are similar in their properties as gasoline blendstocks (both are high octane) and are in fact used as such, aromatics can be considered to be derived from gasoline. In fact, toluene and the mixture of the three xylenes called mixed-xylenes have significant value as gasoline blendstocks, and the economics of aromatics production is intimately linked with gasoline economics. One of the values of the aromatic streams in gasoline is that they have a high octane value in a lead-free gasoline, significantly higher than that of the other major gasoline component, catalytic cracked naphtha (produced from catalytic cracking of V.G.O.), which requires lead to yield a premium grade of gasoline.

The trend towards reduction of lead or even elimination of lead from gasoline has had a marked impact on aromatic chemical economics. Reformate has a current value of about $290-$320 per ton as a component of unleaded gasoline. Toluene, as a component to blend into premium unleaded gasoline, has a current value of around $370 per ton, even in a depressed gasoline market. While gasoline economics generally drives the price for aromatics, there are times when chemical demand has an impact on the production of unleaded gasoline. The shortage of unleaded gasoline at the end of 1978 is at least partially an example of this.

Production of Ammonia

The third basic petrochemical process is, strictly speaking, not a petrochemical process at all. Ammonia, the product being considered, contains no carbon and is an inorganic, not an organic compound. The synthesis gas that is the intermediate product (a mixture of carbon oxides and hydrogen) can be produced from natural gas, naphtha, or coal. But, since the primary feedstocks are natural gas and naphtha, the production of ammonia is frequently classed as a petrochemical process. The final steps in the manufacturing of ammonia are the reaction of a synthesis gas mixture containing carbon oxides, hydrogen, air, and some methane to give methane, nitrogen, and hydrogen (hydrogen to nitrogen ratio 3:1) and then the production of ammonia from the mix at high pressure over an iron oxide catalyst. The synthesis gas can be produced from natural gas or naphtha (or other products as previously mentioned). In recent years, with its increased availability, natural gas has become the dominant feedstock for ammonia production wherever possible. Where natural gas is not available, the economics favors importation of ammonia produced elsewhere from natural gas at the expense of indigenous production based on naphtha.

With natural gas consumption at about 0.75 tons per ton of ammonia compared with use of just over one ton of naphtha per ton of ammonia, the preferential use of natural gas can be seen to make at least partial sense. When some operations charge natural gas to be used to make ammonia at under $25 per ton compared with $270 per ton for naphtha, the rationale behind this trend to use natural gas becomes obvious.

Petrochemical and Feedstock Demands

When the consumption of petroleum products as petrochemical feedstock is referred to, the difference between net and gross consumption must be made clear. For example, the steam cracking of one barrel of naphtha yields about a quarter of a barrel of steam-cracked naphtha. This quarter barrel can go directly to gasoline or be used to produce aromatic chemicals. If it goes to an aromatic plant, the non-aromatic part (about 40 percent), termed rafinate, can be used as a gasoline blend stock or be returned to a steam cracker as an excellent steam cracker feedstock. The processes are fairly complex and the opportunities for components or by-products to "leave" the petrochemical production process and "reenter" the petroleum products field are many. Hence, where feedstock consumption is referred to in this article generally it is the net figure being quoted. This represents the volume of feedstock entering the process less the volume of any products leaving the process that are considered petroleum products themselves.

One of the features of the petrochemical industry since the early fifties has been the tendency to construct more plant capacity than needed. Certainly today, with the expectation of major petrochemical capacity developing in OPEC countries as well as in many LDCs, the major concern of the industry is toward capacity rationalization (involving some capacity shutdown) and a hoped-for return to at least marginally profitable operation.

An additional factor, already referred to, is the big difference between the costs of steam-cracking feedstocks and the volatility that has been a feature of the past ten years, both in terms of absolute price and difference between cost of feedstocks. This is leading to development of much greater flexibility in terms of the feedstock that can be used both for new and existing capacity. Current nameplate capacity (rated capacity of a plant to produce product) is almost always based on use of a specific feedstock or a specific mix. Over the balance of this decade and probably the balance of the century, plants will have to be able to use any of the available feedstocks – gas liquid, naphtha, or V.G.O., depending on the relative prices of the feedstocks and the market for by-products at the time. Development of this flexibility, as well as the capacity rationalization, means that projection of the specific feedstocks that will be used in the future is an intricate and difficult problem.

For example, the general expectation is for natural gas liquids to continue to show a rising share of the steam cracker feedstock mix, though by no means eliminating the alternate feedstocks. The wider range of by-products from naphtha and V.G.O. cracking will act as a buffer, with the by-product prices tending to rise as the proportion of gas liquid feedstock use reduces their proportional yield.

Table B summarizes the forecast of petrochemical demand for WOCA for 1985 and 1990, and compares this with 1980 demand. As can be seen, growth rates average 3.0 to 3.2 percent per year over the decade, which is very modest compared with growths of between 5 and 10 percent in the 1970s.

TABLE B

FORECAST OF WOCA DEMAND FOR MAJOR PETROCHEMICALS

(Million Tons Per Year)

	1980	1985	1990	Average Annual Compound Growth Rate (Percent)
Ethylene	32	36	44	3.2
Aromatics	32	35	43	3.0
Ammonia	46	55	62	3.0

Our forecast of petroleum feedstocks that will be consumed by petrochemical operations is given in Table C. Naphtha still remains the work-horse of petrochemical feedstocks, but other products are growing in significance. The share represented by natural gas liquids increases from 9.9 percent of the total in 1980 to 14.7 percent in 1990, while the share represented by naphtha falls from 59.9 percent in 1980 to 52.5 percent in 1990. This reflects the forecast surplus of gas liquids over this decade combined with an increasing pressure on relative availability of light petroleum products. The total forecast use of feedstocks in 1990 is 299 million tons. If the 61 million tons per year of natural gas is excluded, the remaining 238 million tons of feedstock is equivalent to about 5.2 million barrels per day of petroleum products. This represents over 10 percent of WOCA petroleum product use in 1990, currently forecast at around 51 million barrels per day.

TABLE C

WOCA PETROCHEMICAL FEEDSTOCK FORECAST

(Million Tons Per Year)

	1980	1985	1990
Natural Gas Liquids	20	26	44
Naphtha	121	135	157
Vacuum Gas Oil	13	15	19
Natural Gas	42	50	61
Other	6	10	18
Total	202	236	299

WORLD PETROLEUM HIGHLIGHTS

U. S. Supply and Demand

The improvement in production of crude oil in the lower 48 states that began in mid-1981 has slowed, with December, 1982 production of 7,019 thousand barrels per day being 0.3 percent down on the 7,043 thousand barrels produced in December, 1981. With the current sharp price erosion, it will be interesting to see the extent to which this decline will accelerate. The drop in the lower 48 production has been offset by the rise in production of North Slope crude, and total domestic production closed the year about 1 percent ahead of 1981.

Demand for petroleum products continues to drop, with residual fuel showing the largest fall both in percentage and barrel-per-day terms. The impact of the expected economic recovery on the demand figures will be watched closely. December total product demand of 14.8 million barrels per day is 10.7 percent lower than the demand for December, 1981 and 2.6 percent below the 1982 average. December oil product consumption usually is greater than the yearly average. While the seasonal factors – a very mild winter through December – were unusual, this decline is still very sharp.

Worldwide Supply/Demand

The continued oil glut, and the resulting pressures on oil producing countries to lower crude oil prices have been a major feature of the oil market. Spot prices for product and for crude oil that had been showing a hardening trend through October dropped sharply in December. There is no doubt that demand continued to decline in 1982, but the problems of determining consistent data on crude production, changes in inventory levels, and levels of import from Communist countries have made it difficult to determine quickly the extent of this decline. Overall, it is estimated that the demand for oil products in WOCA, at 45.5 million barrels per day, was 1.5 percent lower in 1982 than in 1981. Since 1979, WOCA demand has declined 6.5 million barrels per day, a drop of 12.5 percent over three years.

Japanese Refinery Spreads

The ex-refinery product prices for Japan, and the estimated crude oil acquisition costs are shown in Table 1. Table 2 shows the resulting refinery spreads.

TABLE 1

CRUDE OIL AND PRODUCT PRICES IN JAPAN

1982

(Dollars Per Barrel)

	SEPT.	OCT.	NOV.	DEC.
Crude Oil	35.00	34.25	34.10	33.90
Gasoline	60.25	58.56	64.16	62.10
Naphtha	31.91	31.95	32.00	32.50
Middle Distillate	50.00	48.60	53.24	51.70
Residual Fuel	34.42	34.80	35.80	33.69

TABLE 2

JAPANESE REFINERY SPREADS

1982

(Dollars Per Barrel)

	SEPT.	OCT.	NOV.	DEC.
High Conversion	8.32	8.48	11.39	10.10
Low Conversion	5.15	5.66	7.97	6.41

Note: High conversion yield: gasoline 18%, naphtha 17%, middle distillate 30%, residual fuel 35%.

Low conversion yield: gasoline 11%, naphtha 9%, middle distillate 20%, residual fuel 60%.

The major cause of fluctuation in refinery spread is the change in the dollar/yen exchange rate. But the yen price for gasoline and naphtha did show an increase over the September to November period and this, coinciding with an improvement in the yen exchange rate in November, led to a sharp jump in margin. This was then followed by a decline in some product prices in yen terms during December that more than offset a fall in crude cost.

European Refinery Spreads

The crude oil and product prices that applied over the period are given in Table 3.

TABLE 3

EUROPEAN CRUDE OIL AND PRODUCT PRICES

1982

(Dollars Per Barrel)

	SEPT.	OCT.	NOV.	DEC.
Crude	33.25	33.50	32.80	32.05
Gasoline	37.10	37.15	36.50	37.10
Naphtha	34.50	34.50	33.00	33.75
Middle Distillate	39.10	39.25	37.15	36.85
Residual Fuel	25.10	25.50	25.20	24.85

As shown in Table 4 on the following page, refinery spreads for high conversion facilities deteriorated in October and November. The recovery in December was mainly driven by improvement in European currencies against the dollar. Low conversion spreads continued negative through the period with some improvement in December.

TABLE 4

EUROPEAN REFINERY SPREADS

1982

(Dollars Per Barrel)

	SEPT.	OCT.	NOV.	DEC.
High Conversion	1.07	0.93	0.51	1.33
Low Conversion	−2.51	−2.50	−2.70	−2.09

Note: High conversion yield: gasoline 30%, naphtha 10%, middle distillate 33%, residual fuel 27%.

Low conversion yield: gasoline 10%, naphtha 10%, middle distillate 25%, residual fuel 55%.

U.S. Refinery Spreads

The decline in the refinery product prices that began in August accelerated sharply in December and even more sharply in January (as shown in Table 5). Thisdecline more than offset the reductions in domestic and foreign crude prices and, as a result, refinery spreads, shown in Table 6, dropped sharply. The January level of $2.63 per barrel for a Type 1 refinery was barely sufficient to cover variable costs. February results will probably be even worse.

TABLE 5

U. S. WHOLESALE PRODUCT PRICES

(Dollars Per Barrel)

	1982			1983
	OCT.	NOV.	DEC.	JAN.
Gasoline	39.68	38.87	36.88	35.25
Kerosine	42.20	42.97	39.97	37.71
No. 2 Fuel Oil	40.06	40.79	37.84	35.64
Residual Fuel	24.78	26.06	24.57	24.03
Crude Acquisition	32.00	32.00	31.00	31.00

Source: IPAA and Chase

TABLE 6

U. S. REFINERY MARGINS

(Dollars Per Barrel)

	Type 1 Refinery	Type 2 Refinery
1975	1.21	0.10
1978	2.39	0.10
1979	4.19	0.84
1980	4.09	−1.97
1981	4.07	−1.77
January, 1982	3.83	−1.74
February, 1982	2.94	−2.22
March, 1982	2.97	−1.77
April, 1982	3.16	−1.27
May, 1982	4.56	−0.31
June, 1982	5.86	0.26
July, 1982	6.13	0.36
August, 1982	5.32	−0.52
September, 1982	5.72	0.30
October, 1982	5.44 (R)	0.21 (R)
November, 1982	5.50 (R)	0.90 (R)
December, 1982	4.27 (E)	−0.10 (E)
January, 1983	2.63 (E)	−1.31 (E)

(R) = Revised, (E) = Estimated

Note: Assumed Type 1 and 2 yields are:

	Motor Gasoline	Kerosine	Distillate Fuel	Residual Fuel
Type 1	50%	8%	25%	17%
Type 2	21%	8%	19%	52%

	DECEMBER			3 MOS. AVERAGE			YEAR-TO-DATE		
	1982	1981	Change	1982	1981	Change	1982	1981	Change
	Thous. Bbls. Daily		− % −	Thous. Bbls. Daily		− % −	Thous. Bbls. Daily		− % −
PRIMARY DEMAND									
Motor Gasoline	6,281	6,681	− 6.0	6,370	6,546	− 2.7	6,504	6,588	− 1.3
(Unleaded)*	3,514	3,440	2.2	3,480	3,298	5.5	3,398	3,240	4.9
Jet Fuel	1,016	989	2.7	998	972	2.7	1,002	1,009	− 0.8
Kerosine	144	199	− 27.6	138	160	− 13.4	124	127	− 2.0
Distillate Fuel	2,943	3,212	− 8.4	2,656	2,966	− 10.4	2,676	2,829	− 5.4
Residual Fuel	1,327	2,250	− 41.0	1,427	2,015	− 29.2	1,663	2,088	− 20.3
All Other	3,108	3,269	− 4.9	3,219	3,353	− 4.0	3,208	3,422	− 6.3
Total Domestic Demand	14,819	16,600	− 10.7	14,809	16,012	− 7.5	15,177	16,063	− 5.5
Exports	810	656	23.5	848	698	21.4	812	595	36.6
Total Demand	15,629	17,256	− 9.4	15,657	16,710	− 6.3	15,989	16,657	− 4.0
New Supply									
Domestic	10,675	10,839	− 1.5	10,844	10,941	− 0.9	10,834	10,818	0.2
Crude Oil	8,620	8,585	0.4	8,645	8,578	0.8	8,663	8,572	1.1
Natural Gas Liquids	1,551	1,590	− 2.5	1,560	1,606	− 2.8	1,543	1,609	− 4.1
Other Supply	504	664	− 24.1	639	758	− 15.6	628	638	− 1.6
Imports	4,430	5,690	− 22.1	4,866	5,507	− 11.6	4,823	5,722	− 15.7
Crude Oil	3,099	4,024	− 23.0	3,356	3,893	− 13.8	3,308	4,150	− 20.3
Refined Products	1,331	1,666	− 20.1	1,510	1,614	− 6.4	1,516	1,572	− 3.6
Residual Fuel	597	916	− 34.8	701	860	− 18.6	738	800	− 7.8
All Other	734	750	− 2.1	809	754	7.4	778	772	0.8
Total New Supply	15,105	16,529	− 8.6	15,711	16,448	− 4.5	15,658	16,540	− 5.3
Crude Oil Refined	11,377	12,744	− 10.7	11,768	12,571	− 6.4	12,108	12,757	− 5.1
Stock Change	−524	−727	−	54	−262	−	−332	−117	−
Stocks – End of Month in Million Barrels									
Gasoline	241	252	− 4.3						
Jet Fuel	38	40	− 5.6						
Kerosine	11	11	− 3.5						
Distillate Fuel	180	190	− 5.6						
Residual Fuel	67	78	− 14.1						
All Other	360	317	13.4						
Total Products	794	890	− 10.7						
Crude Oil	348	364	− 4.3						
Total – All Oils	1,142	1,253	− 8.9						

Totals may not add due to rounding
*Included in motor gasoline

Sources: *American Petroleum Institute*
Chase Manhattan Bank
Department of Energy

The Petroleum Situation

A quarterly publication from Chase Econometrics — THE CHASE MANHATTAN BANK, N.A., NEW YORK, N.Y. 10081

10/24/83 B1900-2

VOLUME 7 – NO. 2
AUGUST, 1983

CHANGING PATTERNS OF WORLD ENERGY CONSUMPTION

The substantial increases in oil prices since 1973 have had tremendous impacts on world energy, and particularly on oil consumption. These impacts have varied across regions and energy types. As shown in Table A, from 1960 through 1973, the real price of internationally traded crude oil, as measured in constant U.S. dollars, changed very little. In this stable oil price environment, Free World energy consumption grew at 5.3 percent per year and oil use rose at 7.5 percent per year, increasing its share of Free World energy consumption from 43 to 56 percent.

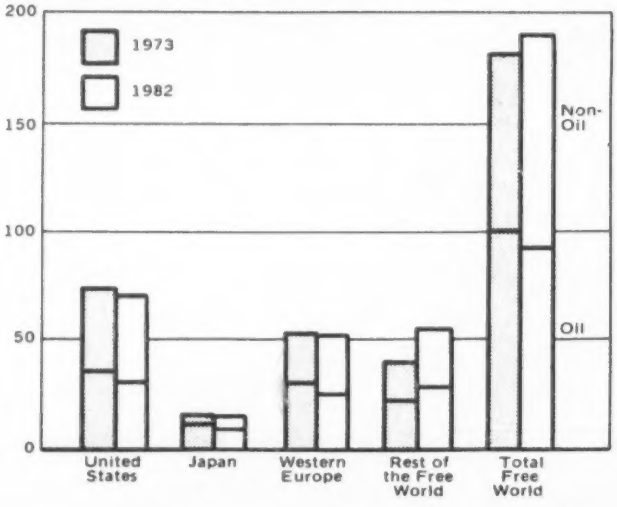
TABLE A
GROWTH IN FREE WORLD ENERGY AND OIL CONSUMPTION AND IN THE REAL PRICE OF CRUDE OIL
(Compound Average Annual Percent Change)

	1960-1973	1973-1982
Energy Consumption	5.3	0.6
Oil Consumption	7.5	−0.7
Real Price of Crude Oil	−0.1	23.0

The nine-year period from 1973 through 1982 shows an almost diametrically opposed picture. Rather than remaining stable, the real oil price multiplied by over 600 percent, for a compound average rate of 23 percent per year. This contributed to a drastic slowdown in energy demand growth to only 0.6 percent per year and to an actual decline in oil demand of 0.7 percent per year. An even greater negative response in energy and oil consumption might have been expected, given the magnitude of the real crude oil price increase since 1973. But two factors have tended to offset the negative impacts of the real crude oil price increase. First, taxes and other non-oil costs of distribution have dampened the pass-throughs of crude oil price changes into final user oil product prices, so that petroleum product prices have increased by smaller percentages than those for crude oil prices. Second, while the sharp rise in oil and energy prices has contributed to a reduction in Free World economic growth from what it would have been, growth has remained positive. The negative response of energy and oil consumption to the increase in prices has been mitigated by the positive response of consumption to increases in Free World economic growth.

Free World energy and oil consumption in quadrillion BTUs by region for 1973 and 1982 are shown in Figure A. The total height of each bar measures total energy consumption and the lower portion of each bar measures oil use. In volume terms, the U.S. led the world in declines in energy consumption, and Europe was the leader in reducing oil consumption. In each of the three industrialized regions, energy consumption declined by small amounts and oil consumption by greater amounts. By way of contrast, in the Rest of the Free World, aggregate energy consumption increased by almost 16 quads, more than offsetting the fall in the industrialized world. Oil use in this group of countries also grew, but only by 5 quads, which was not enough to mitigate the declines in oil consumption elsewhere, so that total Free World oil consumption declined.

FIGURE A
FREE WORLD ENERGY AND OIL CONSUMPTION BY REGION
(Quadrillion BTUs)



Looking at the share of oil in total energy, the polar cases have been the U.S. and Japan. While, thanks to large indigenous resources of coal and natural gas, the U.S. had the lowest share of oil in total energy use in 1973, the nation has also made the least progress in reducing that share. A combination of oil and natural gas price controls for most of the nine-year period, environmental costs of using coal, and growing concern over nuclear power have been responsible for this.

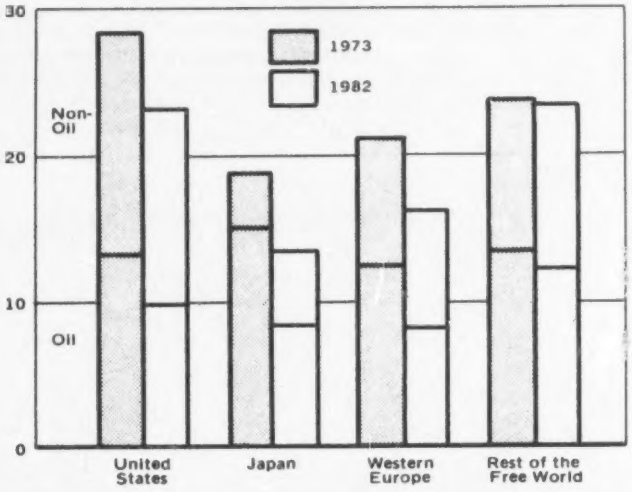
The Japanese continue to have the highest penetration of oil in total energy use, 63 percent in 1982, compared to no more than 51 percent in any of the other regions shown. But Japan has made the most progress in reducing that penetration, by some 17 percentage points since 1973. Japan has had to turn largely to nuclear power and various forms of imported energy to replace oil. It has increased its use of nuclear power by an average of 32 percent per year since 1973, about twice the rate of growth experienced in the U.S. Nuclear power in Japan accounted for nearly 8 percent of total Japanese energy consumption in 1982, up from less than 1 percent in 1973.

As shown in Figure B, on a per unit of real GNP basis, Japan has also been the leader in reducing energy intensity. In the three industrialized regions, a significant degree of energy-intensity reduction has taken place, while little has occurred in the Rest of the Free World. In the industrialized regions, some of the aggregate conservation has come from a shift in the industrial mix toward less energy-intensive manufacturing processes and services and away from energy-intensive heavy manufacturing. Five industries are particularly energy-intensive relative to other manufacturing industries. They are, in order of energy intensity, paper, petroleum refining, chemicals, primary metals, and cement. In the U.S. and Western Europe, and even in Japan, the relative importance of these industries has shrunk dramatically, while in the Rest of the Free World it has increased. For the U.S. alone, the relative decline in these five smokestack industries has accounted for about 30 percent of the total amount of aggregate energy conservation that occurred between 1973 and 1982.

FIGURE B

FREE WORLD ENERGY AND OIL INPUT PER UNIT OF REAL GNP

(Thousand BTUs Per Dollar of GNP in 1982)



Among the industrialized nations, in both periods, Japan has had the lowest level of energy intensity and has achieved the biggest improvement (i.e., decline). In general, Japan's greater efficiency has not been due to a radically different economic structure, but instead primarily to greater energy efficiency in each use. While data is hard to come by, analysts feel that, for example, Japan uses less energy per vehicle mile traveled, and per ton of steel, paper, and cement produced. But Japan's economic structure is also more oriented toward energy conservation. For example, Japan depends more on mass transit and has more crowded housing conditions than does the U.S. As demonstrated above, Japan has also done the best job in terms of switching away from oil toward other forms of energy.

As shown in Table B, the pattern of changes in oil product prices from 1973 to 1982 was much the same across regions, but not across products. Note that in all regions, much of the real increases in crude oil costs were passed through to residual oil prices. This is because residual oil must be sold at or near the cost of crude oil owing to the interchangeability of residual oil and crude oil in the combustion process. Unless residual fuel is priced at or below crude oil, the consumer would use crude instead. For the same reason, residual fuel is completely or almost completely untaxed. The percentage price increases for distillates have been much lower than those for residual fuel, partly because distillate fuel prices started at a higher base, three to four times as high as residual prices in 1973. Further, prices have not increased at the same rates in the different regions, primarily because of differing tax policies. Prices in Japan increased faster than they did elsewhere.

TABLE B

GROWTH IN THE REAL PRICE OF OIL PRODUCTS BY REGION, 1973-1982

(Compound Average Annual Percent Change)

	Imported Crude Oil	Residual Fuel Oil	Distillate Oil	Motor Gasoline
United States	20.5	16.1	9.3	5.8
Japan	21.2	17.5	10.4	5.2
Western Europe	19.2	15.8	8.8	3.5

For motor gasoline, the U.S. has led the field in terms of price increases with a 5.8 percent compound average annual growth over the period, although the price increases have been much smaller in all three regions than they were for either distillate or residual. This is partly a function of the very much higher base which existed for gasoline prices in 1973. In Europe and Japan in 1973, taxes and import duties accounted for over 50 percent of the total price of gasoline. A gallon of gasoline in 1973 in Japan cost 83 cents compared to 40 cents in the U.S. In Europe, the price ranged from 78 cents per gallon in London to $1.18 in Bonn, West Germany. All the differences were due to taxes.

While the price of residual fuel oil increased the most of any major oil product, the consumption of residual fuel oil decreased the most. All industrialized regions experienced large declines in residual fuel oil use between 1973 and 1982, as shown in Table C.

TABLE C

FREE WORLD RESIDUAL OIL CONSUMPTION BY REGION

(Million Barrels Per Day)

	1973	1982	Compound Average Annual Percent Change
United States	2.8	1.7	−5.5
Japan	2.6	1.4	−6.5
Western Europe	4.5	2.9	−4.9
Rest of the Free World	3.2	3.6	1.4
Free World	13.1	9.6	−3.4

Only in the Rest of the Free World was there an increase in the use of residual fuel oil, as this part of the Free World grew more rapidly, and as the smokestack industries shifted toward this region. But the small increase in residual fuel consumption here was not nearly enough to offset the large declines elsewhere, so that total Free World residual fuel oil consumption declined sharply. This reduction in residual fuel oil consumption accounted for nearly all of the decline which took place in Free World oil consumption between 1973 and 1982.

The primary markets for residual fuel oil in the industrialized regions are electricity generation, heavy manufacturing, and bunker fuel for shipping. Sales in each of these markets have declined. Residual fuel use for electricity generation has dropped sharply due to substitution of coal and nuclear for base-load requirements. With respect to heavy manufacturing, there has been some substitution away from residual fuel, towards coal, natural gas, and electricity, which in turn has become more heavily oriented toward coal and nuclear. Other major factors in the decline in residual fuel oil consumption have been the large drop in heavy manufacturing output itself and the complete conversion of the cement industry away from residual fuel to coal. In shipping, there has been both a large drop in output, with the collapse of the world oil tanker market, and also some substitution of diesel fuel for residual fuel.

As shown in Table D, the responses to the changes in the price of distillate oil have varied among regions, which is unlike the case for residual fuel, where there were similar patterns across regions. Price, while an important factor in consumption of distillate fuel, is not the only story. In the range of middle distillates, the competition comes not so much from

coal, but from natural gas and, in such applications as space heating and machine drive, from electricity. The prices of these alternatives have been rising quickly, particularly for Japan. Liquified natural gas, a major competitor for distillate oil in Japan, has been priced on an oil-equivalent basis. This would help explain why Japan, which experienced the fastest growth in distillate prices, also was the only industrial area to increase its use of distillate fuel over the period.

TABLE D

FREE WORLD DISTILLATE OIL CONSUMPTION BY REGION

(Million Barrels Per Day)

	1973	1982	Compound Average Annual Percent Change
United States	3.3	2.8	−1.8
Japan	1.0	1.2	1.4
Western Europe	5.1	4.4	−1.7
Rest of the Free World	3.4	4.2	2.7
Free World	12.8	12.6	−0.2

In the Rest of the Free World, distillate fuel oil consumption increased, as was also the case for residual fuel oil. In combination with Japan, the increase was just about enough to offset declines in the rest of the industrialized world, leading to almost no change in Free World distillate consumption.

As shown in Table E, the U.S. was the only industrialized region to achieve a decline in motor fuel consumption, for several reasons. First, prices rose most rapidly here. The U.S. moved from the lowest base with respect to the average fuel economy of its fleet of cars, and has achieved greater rates of improvement. This improvement has come from a shift toward smaller cars, but even more important, from considerable improvement in fuel efficiency for any given sized car, as measured by occupant capacity. In Europe and Japan, rising real gasoline prices also brought on mix shifts and greater fuel efficiency for given sized cars, but these effects were smaller than they were in the U.S., and not enough to offset increases in fuel consumption coming from rising real income levels and associated greater rates of car ownership and miles traveled. In the Rest of the Free World, motor gasoline consumption increased by a fairly substantial amount, due to expanding automobile use in such areas as Latin America and Southeast Asia. This increase brought the net increase for the Free World as a whole to about one million barrels per day over the period.

TABLE E

FREE WORLD MOTOR GASOLINE CONSUMPTION BY REGION

(Million Barrels Per Day)

	1973	1982	Compound Average Annual Percent Change
United States	6.7	6.5	−0.2
Japan	0.5	0.6	2.9
Western Europe	2.1	2.4	1.7
Rest of the Free World	2.3	3.2	3.9
Free World	11.6	12.7	1.2

Now let's briefly consider what will happen to growth in energy and oil consumption through 1990. Our best estimate forecasts are shown in Table F along with our best estimate forecast of the growth in the real price of crude oil. It should be noted that there are considerable risks to this oil price outlook, particularly on the down side. Our Best Estimate 1982 to 1990 forecast for growth in the real crude oil price is quite similar to the real crude oil price growth experience of the 1960 to 1973 period. Nevertheless, despite the similarity in the price outlook, it is our Best Estimate forecast that energy and oil consumption will grow much less rapidly over the 1982 to 1990 period than they did over the 1960 to 1973 period.

TABLE F

GROWTH IN FREE WORLD ENERGY AND OIL CONSUMPTION IN THE REAL PRICE OF CRUDE OIL, 1960-1973, 1973-1982, AND 1982-1990

(Compound Average Annual Percent Change)

	1960-1973	1973-1982	1982-1990
Energy Consumption	5.3	0.6	2.0
Oil Consumption	7.5	−0.7	1.5
Real Crude Oil Price	−0.1	23.0	0.1

There are two primary reasons why rates will be slower in the 1980s than they were in the 1960s. First, we expect that real world economic growth will be less rapid during the 1980s than it was during the 1960s. Second, and even more important, it is anticipated that most of the trends toward energy and oil conservation which have occurred in the post-1973 period, while not continuing at their past rates, will also not be reversed. For instance, in the case of residual fuel oil in base-load electricity generation, substitution toward coal and nuclear will not proceed as rapidly as it has in the past, but at the same time, it is not anticipated that existing base-load coal and nuclear facilities will be replaced with oil-burning facilities.

Likewise, with respect to the impact of increased installation of home insulation in cutting residential distillate fuel oil sales, we anticipate that the number of insulation retrofits will be far smaller than recent experience and that insulation standards for new homes will not continue to increase, but also will not significantly decline. The net impact of such anticipated future trends will be to bring in energy and oil consumption growth trends lower than those in the 1960s but greater than those in the 1970s.

Susan Haltmaier Todd
Second Vice President

WORLD PETROLEUM HIGHLIGHTS

U.S. Supply and Demand

On average, domestic crude oil production has been running slightly ahead of year-ago levels. Both lower 48 and Alaskan production are averaging modest gains, based on revised 1982 data. Currently, Alaskan production is 1,707 thousand barrels per day, out of a total U. S. crude production of 8,695 thousand barrels per day.

Demand for petroleum products had been lagging behind 1982 levels through May. In June, demand surged ahead by 2.6 percent compared to last year, but July's increase was a modest 0.3 percent. Jet fuel, distillate fuel, and gasoline demand increased, with jet fuel and gasoline now showing demand higher than it was in 1982 on a year-to-date basis. The decline in residual fuel demand slowed in June, to −14.6 percent, compared to the six months' average to date of −23.0 percent, but July demand fell to 17.3 percent below 1982.

Unusual seasonal patterns and the beginning of a turnaround in economic activity are two of the reasons for this recovery in U.S. petroleum demand. Further improvement is expected in the second half of 1983.

Worldwide Supply and Demand

OPEC production has been recovering steadily since reaching a low point in March of close to 13 million barrels per day, and was at its 17.5 million barrel per day ceiling in June. By the end of July the level was about 18 million barrels per day.

A large part of the increase in OPEC production is the result of a halt in the massive speculative inventory decumulation which began last year and reached its peak in February/March of this year. At one point in late February, it was estimated that oil stocks possibly were being depleted at the rate of 6 million barrels per day. At present, there appears to be a small accumulation. In the United States, combined inventories of crude plus products, excluding oil held in the Strategic Petroleum Reserve (SPR), were unchanged at the end of June, compared with a month earlier. When SPR inventories are included, there was a modest build. A build of over 15 million barrels occurred in July.

Total Free World oil demand was estimated at 45.0 million barrels in the first quarter of 1983, falling to an estimated 43.0 million barrels per day in the second quarter. Demand in the second half of 1983 should improve, leading to an increased call on OPEC production.

U.S. Refinery Margins

Shown below, refinery product prices have recovered from the low points they hit at the time of the decline in the OPEC marker crude oil price to $29 per barrel in March, 1983. These increases have led to substantial improvements in refinery margins through June for both Type I and Type II refiners. A Type I refiner represents a medium conversion operation yielding gasoline (50%), kerosine (8%), middle distillate (25%), and residual fuel (17%). A Type II refiner represents a topping operation yielding gasoline (21%), kerosine (8%), middle distillate (19%), and residual fuel (52%). Type I refiners, with a gross margin of over $5 per barrel in May through July, are doing very well. Type II refiners showed a narrowly positive gross margin in May for the first time since November, 1982 and this has continued through July. On average, the Type II gross refinery spread has been below zero since 1980.

U.S. REFINERY MARGINS

(Dollars Per Barrel)

		Type I	Type II
1981		4.00	(1.84)
1982		4.66	(0.47)
1983	January (R)	2.87	(1.05)
	February	2.90	(0.86)
	March	2.33	(1.02)
	April (E)	3.50	(0.36)
	May (E)	5.05	0.76
	June (E)	5.17	0.81
	July (E)	5.25	0.91

(R) = Revised, (E) = Estimated

European and Japanese Refiner Margins

As indicated below, the improvement in European margins over the spring was most impressive. At the summer, margins indicated most conversion refiners will be covering their full operating costs.

In addition, the summer improvement resulted in some stabilization in the Japanese position as product prices declined by less than crude costs. With the Japanese cost structure, a margin of under about $9 per barrel indicates a loss. Hence, the Japanese refiners were showing very poor results over the winter.

EUROPEAN & JAPANESE REFINER MARGINS

(Dollars per Barrel)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.
EUROPE						
Crude	31.60	30.65	29.50	29.20	28.90	28.75
Gasoline	36.25	35.75	35.50	35.95	36.50	37.10
Naphtha	33.25	33.00	33.00	33.00	33.00	33.25
Middle Distillate	34.50	33.00	33.25	33.65	34.80	34.80
Residual Fuel	24.80	24.80	24.75	24.85	24.90	24.95
High Conversion	0.68	0.96	2.11	2.70	3.56	3.93
Low Conversion	−2.38	−1.88	−0.72	−0.22	0.45	0.71
JAPAN						
Crude	33.90	33.90	33.50	30.50	29.75	29.50
Gasoline	62.00	62.00	57.25	57.00	58.00	58.00
Naphtha	32.00	32.00	32.00	32.00	32.00	32.00
Middle Distillate	50.15	50.15	49.10	47.25	47.20	46.80
Residual Fuel	33.50	33.50	32.75	32.50	32.50	31.85
High Conversion	9.47	9.47	8.44	10.75	11.67	11.57
Low Conversion	5.93	5.93	5.15	7.60	8.45	8.23

U. S. Oil Highlights

	JULY 1983	JULY 1982	JULY Change – % –	3 MOS. AVERAGE 1983	3 MOS. AVERAGE 1982	3 MOS. AVERAGE Change – % –	YEAR-TO-DATE 1983	YEAR-TO-DATE 1982	YEAR-TO-DATE Change – % –
	Thous. Bbls. Daily			Thous. Bbls. Daily			Thous. Bbls. Daily		
PRIMARY DEMAND									
Motor Gasoline	6,876	6,799	1.1	6,814	6,753	0.9	6,548	6,540	0.1
(Unleaded)*	3,053	3,574	– 14.6	3,491	3,515	– 0.7	3,461	3,347	3.4
Jet Fuel	1,098	986	11.4	1,073	993	8.1	1,040	1,003	3.8
Distillate Fuel	2,286	2,084	9.7	2,370	2,325	2.0	2,605	2,774	– 6.1
Residual Fuel	1,212	1,466	– 17.3	1,261	1,507	– 16.3	1,407	1,811	– 22.3
All Other**	3,346	3,439	– 2.7	3,294	3,275	0.6	3,285	3,295	– 0.3
Total Domestic Demand	14,818	14,774	0.3	14,812	14,852	– 0.3	14,895	15,422	– 3.4
Exports	806	741	8.8	752	750	0.3	814	793	2.7
Total Demand	15,624	15,515	0.7	15,564	15,602	– 0.2	15,709	16,215	– 3.1
New Supply									
Domestic	10,761	10,773	– 0.1	10,883	10,822	0.6	10,941	10,843	0.9
Crude Oil	8,695	8,649	0.5	8,685	8,663	0.2	8,673	8,656	0.2
Natural Gas Liquids	1,510	1,521	– 0.7	1,538	1,515	1.5	1,559	1,540	1.3
Other Supply	556	603	– 7.8	660	644	2.5	709	647	9.6
Imports	5,369	5,628	– 4.6	4,896	5,100	– 4.0	4,320	4,746	– 9.0
Crude Oil	3,697	4,147	– 10.9	3,297	3,645	– 9.5	2,816	3,220	– 12.5
Refined Products	1,672	1,481	12.9	1,599	1,456	9.8	1,504	1,526	– 1.4
Residual Fuel	679	576	17.9	618	652	– 5.3	658	767	– 14.1
All Other	993	905	9.7	981	803	22.1	846	759	11.4
Total New Supply	16,130	16,401	– 1.7	15,778	15,923	– 0.9	15,262	15,589	– 2.1
Crude Oil Refined	12,270	12,896	– 4.9	11,975	12,686	– 5.6	11,596	12,170	– 4.7
Stock Change	506	886	–	214	321	–	–447	–626	–
Stocks – End of Month in Million Barrels									
Gasoline	226	226	0.0						
Jet Fuel	41	40	2.9						
Distillate Fuel	129	148	– 13.1						
Residual Fuel	48	59	– 18.4						
All Other**	291	309	– 5.8						
Total Products	735	782	– 6.1						
Crude Oil	346	345	0.5						
Total – All Oils	1,081	1,127	– 4.1						

Totals may not add due to rounding
*Included in motor gasoline
**All Other now includes Kerosine

Sources: *American Petroleum Institute*
Chase Manhattan Bank
Department of Energy